DOCUMENT RESUME

ED 349 965 IR 015 704

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TITLE Technology-Mediated Communities for Learning: Designs and Consequences. Technical Report No. 21.
INSTITUTION Center for Technology in Education, New York, NY.
PUB DATE Feb 92
NOTE 14p.
PUB TYPE Information Analyses (070) -- Viewpoints (Opinion/Position Papers, Essays, etc.) (120) -- Reports - Descriptive (141)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Computer Networks; Cooperative Learning; *Distance Education; *Educational Television; Electronic Mail; Electronic Publishing; Elementary Secondary Education; Global Approach; Higher Education; *Hypermedia; Instructional Effectiveness; *Interactive Video; International Programs; *Research Needs

ABSTRACT

This paper posits that exploration of and judgment about distance learning at this point in time require the examination of three interrelated topics: (1) What new forms and images for school have been created and tried? (2) What issues arise as experiments in distance learning are developed and maintained? and (3) What is the effect of these forms on the quality of learning and the social fabric of schooling? The report then describes a general framework for thinking about work thus far in distance learning, and provides a brief synthesis of five categories of issues that have arisen, i.e., issues of technology functioning, community creation and definition, discourse, activity definition, and quality control. It is noted that indicators of the effective integration of technologies in schools include such features as emphasis on thinking rather than memorizing, collaborative work, engagement with complex tasks and projects, differentiated roles for teachers, and access to and active integrated use of a wide variety of resources. Four different exemplars of distance learning experiments and projects are briefly described, i.e., national and international collaborative scientific activity through the networking projects of the Technical Education Research Centers; writing about problems investigated by participants in a networked Global Issues Learning Circle and publishing an electronic journal; the "Jason" Project, which uses satellite-based interactive video; and the Continents Project, which uses a hypermedia system to share course materials in a nationally distributed community of interdisciplinary faculty. A summary of thoughts about a research agenda to ask and answer questions about the value of these forms concludes this report. (Contains 21 notes.) (BBM)

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Technology-Mediated Communities for Learning: Designs and Consequences

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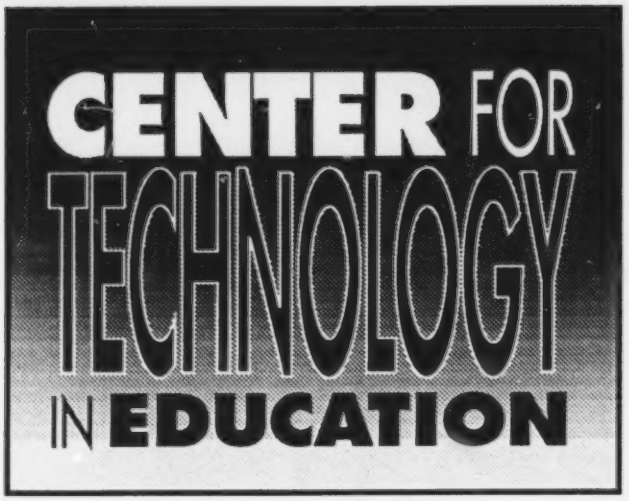

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Tech. Rep. No. 21

TECHNOLOGY-MEDIATED COMMUNITIES FOR LEARNING: Designs and Consequences

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Distance learning has become increasingly prominent in discussions of educational change. It holds promise of external learning beyond the physical confines of traditional schools, creating new forms of community. During the last decade, considerable experience has accumulated through projects that have implemented different innovative visions of distance learning. Five groups of issues have emerged that affect the success of projects: they are technology functioning, community creation, discourse forms, activity definition, and quality control. Several projects illustrate the influence of these factors in different contexts. The first research phase allows us to understand how the potential of the technologies can best be used and what supports are needed to ensure that these innovations are robust. The second phase of research asks questions about the impact of distance learning on cognitive and social functioning. These questions can be legitimately asked only from the prior sustained platform of practice.

The notion of distance learning has had an increasingly prominent presence in discussions of educational change in recent years as technologies that support new visions of schooling have become refined and relatively accessible to us all. The visions encompass multiple and quite disparate strategies for expanding learning far beyond the physical confines of school walls by harnessing mediating technologies such as electronic networks in a variety of configurations, video and interactive video that make use of new information channels such as satellite broadcast or optical fiber, and large databases that include hypermedia capabilities.

This paper has also appeared in the Annals of the AAPSS, 514, March 1991.

The claims and rationales for developing various interpretations of distance learning range from better use of scarce resources in traditional instructional designs—for example, using interactive broadcast media to bring teleteachers to isolated schools—to quite innovative visions that substantially alter schooling, such as video and fiber-optic links to bring students aboard a scientific research vessel to interact with scientists and participate directly in research.

Overview

What does experience thus far with creating and implementing different visions of distance learning tell us about these images in practice and their value in

improving learning circumstances for students? For current purposes, "distance learning" refers to electronically mediated activity between students, teachers, and information sources that are separated by significant geographical distances. Exploration of and judgment about distance learning—at this point in time—require the examination of three interrelated topics: (1) What new forms and images for school have been created and tried? (2) What issues arise as experiments in distance learning are developed and maintained? (3) What is the value of these new forms? In particular, what is their effect on the quality of learning and the social fabric of schooling?

A general framework for thinking about work thus far in distance learning will be described. This will be followed by a brief synthesis of four categories of issues that have arisen as the images have been implemented in real social fabrics and worn over time—topic 2. Four different exemplars of distance-learning experiments and projects will then be briefly described to flesh out the images a bit and to articulate the general issues with the different views of them in practice; this description will integrate topics 1 and 2. Finally, to explore topic 3, thoughts about a research agenda to ask and answer questions about the value of these forms will be summarized.

Background

Sufficient experience with various forms of distance learning has accumulated over the last decade to draft some answers to the preceding questions. "Draft" is an important word, because the rapid pace of technological change means that answers remain moving targets. But initial and robust steps have been taken by the enduring experiments; through these experiences, distance learning was transformed from an abstract concept to a set of images for education.

Unlike the business world, which had familiar organizational, training, and communications tasks to act as hooks for assimilating emerging electronic capabilities that link information and people across distances, the hooks in our educational system were few and fragile. In workplaces, when the capabilities were used for familiar purposes, entirely new functions and organizations could evolve in a second stage of appropriation.[1] But technology-mediated distance learning was an almost entirely foreign venture for schools.[2] In the educational world of kindergarten through twelfth grade, there is, in most places, a relatively narrow band of activities that these technologies make more efficient. As has been often noted, our classrooms tend to be quite self-contained in terms of interactive relationships and resources. Learning overwhelmingly takes place in a carefully bounded physical space with one or two adults; resources are generally local to the classroom or the school. While there is considerable talk about expanding schools beyond their walls, with the exception of the odd field trip, this self-containment has proved remarkably robust, reflecting practical difficulties of moving minds and bodies around and conceptual frameworks about what it is to learn and communicate knowledge.

Many designs for distance learning open up possibilities for new kinds of interactions through alternative arrangements of space, time, and resources for teachers and students. Some of the initial projects seized the opportunity and enlisted technologies to make practical new kinds of relationships between people and ideas. Initial experiments in distance learning had to build images, infrastructure, and new forms of learning collaboration and discourse from the ground up. They often wrestled with knotty problems posed by an understanding of education long entrenched within—and carefully customized to—four literal walls.

Questions concerning the value of distance learning are just beginning to be addressed. Asking about social and cognitive effects of new instructional forms becomes meaningful only when there is a sufficient, sustained platform of experience in a variety of practical settings. A slender collection of research of this sort has been compiled thus far, but the accumulated experience in designing and implementing forms of distance learning is becoming sufficiently rich to begin to address these topics.

Framework for Changed Learning Environments

Electronically mediated distance learning is an extremely important notion to explore, critically examine, and understand because of the power it may offer to conduct education very differently. Our educational system is now undergoing severe scrutiny since the circumstances for educating all students broadly, deeply, and flexibly do not

now exist. The capacities offered by distance learning may be well enlisted for this purpose.

To create high-quality, humane educational circumstances, fundamental features of the current norm must change. Creating learning environments that provide for "cognitive apprenticeships" is one way of characterizing such change.[3] In these circumstances, students are carefully guided through work on complex, meaningful, and authentic tasks as contexts for learning and flexibly applying knowledge and strategies. Students need to work in circumstances where coaching, scaffolding, and opportunities for articulation, reflection, and collaboration characterize their interactions with adults and other learners. Students need to participate in a vibrant educational culture where work is intrinsically motivating and lively interaction between learners and experts embodies and surrounds their activities. In related work concerning the effective integration of technologies in schools, we have been especially interested in identifying the indicators that have been shown to be affected by technologies. These indicators include such features as emphasis on thinking rather than on memorizing or decontexted learning, significant collaborative work, sustained engagement with complex tasks and projects, differentiated roles for teachers, and access to and active integrated use of a wide variety of resources.[4]

Experiences thus far suggest that some designs for distance learning alter key features of classroom interactions in these ways. Ultimately, research about the effectiveness of different forms of distance learning needs to index the innovations to desired goals for change—to examine effects in terms of the broad agenda for improvement in schooling. This article reflects a particular point of view about the kinds of change needed.

Issues in the Development of Distance-Learning Projects

Model projects in distance learning have been undertaken in a number of places and have spanned the available mediating technologies. Taken together, they constitute the first stage of research—to design, monitor, and revise images of distance learning through projects in actual settings. These projects have proved to be difficult and often frightfully complex to carry out and sustain. Researchers encounter problems in practical issues of working with technologies under development; problems in coordinating the many technologies and providers necessary to the project, such as combinations of satellite, microwave, cable, fiber-optic, and telephone channels; participants who are novices to both the ideas and the tools; and problems in coordination within and across schools whose work and schedules are not organized to accommodate so-called invaders that enter through electronic networks or satellites.

There now exist a number of distinctive projects that have considerable depth of experience.[5] With few exceptions, the research thus far is, appropriately, largely formative or case-study material. Rich descriptions of the development and characteristics of different implementations and the supports and structures required to make them work are essential to understanding the role and consequences for new forms of mediated learning. These reports, taken together, offer a composite picture of the issues that are raised and resolved in these projects.

As noted previously, one interpretation of distance learning has been to augment and support traditional modes of teaching and learning. In some cases this has involved supplementing resources, for example, with access to large databases through telecommunications; in other cases, resources that would not otherwise be available are provided, such as interactive video-based courses in subjects—for example, Russian or physics—that schools cannot themselves afford to deliver in person. The research question normally asked is, "How do student outcomes in distance-learning arrangements compare with the standard way of teaching the material?" If the answer is, "At least the same, and cheaper," the design may be considered a success.

In the case of teleclasses, teachers are geographically separated from their students but are present in real time through video images; two-way interactions between teachers and students take place through audio—by means of telephone links, two-way video, or graphics. The interactivity adds a new component to an older form of lecture over broadcast television because students can now interact with the distant teacher or students in other locations through two-way audio or video links. The technology enables the efficient stretching of human expertise to reach more students over longer distances.

The few studies that have been done thus far

suggest that teleclasses are at least tolerable and often enjoyable to students and that there is no indication that they learn less through this arrangement than in traditional classrooms.[6] In addition, as has been the case in business settings, technologies originally used to make current practice more efficient often have second-order effects of changing the practices themselves.[7] For example, interesting issues have begun to emerge concerning the characteristics of good teaching and teachers in these distant arrangements and about the kinds of interactions that take place between distant students and teachers through these media. Questions about how these arrangements can be used to create more vibrant learning environments by combining distance capabilities with local activity appear. These second-order issues suggest a transformation from an approach conserving traditional learning modes to one using these supports to change features of school environments.

A second group of projects begins by interpreting distance-learning capabilities to support new kinds of learning environments and practices. They address the question, "What new activities and communities do these technologies afford that can change the educational landscape in valued ways?" These experiments often grow out of commitments to changing particular features of that landscape—for example, promoting collaborative learning, bringing global conversations to the classroom, providing new kinds of mentor relationships—while enlisting and exploring distance-learning innovations in the process. The projects that will be briefly described here exemplify some of this work.

Since the hooks to readily assimilate these new activities into the ordinary classroom are few, segues from existing circumstances into substantial use of the new resources needed to be written. At the outset, there was very little conceptual or physical/technical framework in place on which to build readily. But today there are a number of detailed images as well as a depth of experience about the issues that arise in practical settings as they are developed and revised. Five overall categories emerge from a synthesis of research thus far.

1. Practical Issues of Technology Functioning

The category of practical issues of technology functioning encompasses fundamental problems of these innovative projects and, by all accounts, requires enormous thought, energy, and patience. The particular components of an electronic network or videosystem need to be selected, customized, or developed; implemented on site, resolving problems such as lack of phone lines in classrooms; organized and coordinated— arranging for a telecourse can involve many collaborators from private and public sectors; and maintained over time, with adaptation or upgrading as needed. In addition, teachers and students need to be taught to use the technologies and to think flexibly about incorporating them into learning. Initially, finding one's way through the options in electronic networking space, for instance, can be a daunting and confusing process.

Early experiments[8] devoted considerable resources to piecing together systems that could work within severe constraints; the available hardware and software did not fit the needs of schools well. A key problem was, and continues to be, cost distribution for the use of outside-school communication links. Many technical design and support problems have been relieved by advances in hardware, refinement of interface design, and the wisdom of these early experiences. But the practicalities of creating and maintaining the technical infrastructure that needs to function smoothly and invisibly for distance learning remain a significant venture, and the technologies rapidly evolve.

This complex set of issues is extensively addressed elsewhere. Current and practical advice and information about options for schools in the worlds of electronic networks is comprehensively available in Roberts et al. Discussions of the technological issues in distance learning can be found in the report of the Office of Technology Assessment . Creative second-generation technical designs are discussed, for example, by Newman, who addresses seamless links between local area networks that support local collaborations creatively combined with limited but well-supported portages to the large national network system, and Levin.[9]

2. Issues of Community Creation and Definition

Some version of the problems encountered in trying to create communities that are organized through electronic mediators is found in the documentation of most distance-learning experiments.[10] It is also an important consideration for the use and effectiveness of these technologies in business and university set-

tings.[11] The nature of a distance-learning community is novel to most teachers and students, and early projects discovered that particular qualities were associated with active, robust communities and needed to be supported. In electronically mediated exchanges, the features one knows about the other participants are different from those discovered in face-to-face or telephone interactions, and features of anonymity peculiar to each new form affect properties of the interaction. For example, without any physical cues, the age of a communicative partner is not known, nor is anything about ethnic identity or physical disability. The conversation, or information exchange, is asynchronous in many cases, and norms about responsibility for and timing of response need to be established. The use of text or visual media for informal exchange over geographical distance appears to support new communicative dynamics.

Expectations for what it means to participate in the community, and coordinating meaningful collective work or exchange are part of the ongoing definition of a social fabric for these media in education. It is a social world that is emergent, whose norms for interaction and purposes for communication become defined in practice. Many of the projects documented the emergence of community in distance learning as they evolved, as problems arose, as communities developed and dispersed.

3. Issues of Discourse

The issues of discourse are related to community creation but encompass a finer-grained look at the qualities of discourse that takes place over distance-learning channels. There has been increasing interest in the kinds of conversation that take place through these media—information type, structure of discourse, pragmatics.[12] There is interest in what topics are discussed and how often; how the information is organized; who participates in exchanges and how their knowledge of coparticipants affects communications; what features characterize discourse that is sustained over turns and time; and how texts or audio- or video-based communications are structured, responded to, and used in work that takes place away from the electronic mediation. An important data source for this aspect of research is the record of messages and interactions, which can be analyzed for their discourse properties.

4. Issues of Activity Definition

The experience of the last decade underscores the importance of carefully structuring the activities that organize the distance-learning work. This appears to be true for all age groups and interpretations of distance-learning capacities. Examination of multiple efforts suggests key features that need to be considered. These include activities that grow out of a real reason to collaborate or communicate with others across distances, activities that structure the communicative exchange or information retrieval around carefully designed problems, activities that support collaborative work through the customized design of the software and/or the materials that coordinate the work, and a coordinator responsible for assuring the smooth flow of information throughout the community and who helps with problems.[13]

Successful tasks have emerged from considerable reflection, revision, and increasingly precise definition of activities that often began as relatively unstructured and that were shaped by the demands of classroom practice. Given the lack of direct fit of the most original uses with traditional activities and organizations of schools, it has not proved particularly effective to simply make the technologies available and watch what happens. On the contrary, considerable effort must go into creating, testing, and revising tasks and activities that make sustained use of the potential and into creating the infrastructure that allows these activities to actually work over time.

5. Issues of Quality Control

In a number of interpretations of distance learning, issues of what gets shared over an often public and expensive medium and who makes, coordinates, or controls those judgments have arisen. In education, quality control has a particular coloring, grown from our deeply familiar model of traditional self-contained classrooms in which teachers, whether they want to or not, largely mediate outside exchanges. When students have ready access to a flexible communication medium, implicit formal and practical assumptions about control of communication become explicit. It is a two-way problem: not only what leaves the classroom for the larger world but also what comes into the classroom is at issue. For many of the experiments, there is no centralized broker to edit or screen information. Are canonical forms of information made avail-

able to students only after some screening process, or is information part of a flexible, unedited exchange between participants? The expense of using these channels is no small consideration. Significant issues are raised by these technologies about the control of information within and across classroom boundaries and about the nets that are erected for screening or editing information at either end of an exchange or through a centralized broker.

Exemplar Projects

Four quite different distance learning projects will be used as vehicles to illustrate how these five categories of issues emerge and are, at least in part, resolved. The projects are in different stages of development and realization, from well practiced and revised to partway off the drawing board. Each of the projects is grounded in a different organizing principle. These principles relate distance-learning opportunities to some familiar activity, based on something recognizable to teachers and students, yet extending the familiar in a new direction.

Networking Projects of Technical Education Research Centers

Several projects of the Technical Education Research Centers (TERC) use electronic networking technologies to support collaborative scientific activity across national and international spans. National Geographic Kids Network is a project that supports collaborative science activities among elementary classrooms. Participating schools receive customized telecommunications and data-gathering and analysis software, and also materials that support hands-on scientific inquiry activities that are carried out at each school. In one cycle of activity, students in each participating school collect data about acid rain in their region, analyze it locally, and use the network to add it to a national database. All schools have access to this set of pooled data to use for their own analyses. They can also communicate with students and teachers in participating classrooms in other schools. In addition, in structuring a real problem that requires a distance-learning solution, students contribute to publicly useful data sets; the widely distributed schools can add many new data points for study of acid-rain patterns throughout the country.

The TERC Star Schools Project structures similar kinds of national collaborative scientific inquiry projects for older students, in middle schools.[14] For example, students and teachers in participating schools collect and share information about radon in their area or solutions to an engineering design problem that makes the best use of limited materials. The project also supports network-based communication about mathematical ideas. Students share their ideas and solutions for problems that range from construction of geometric figures to number theory, in a way analogous to network-supported international scientific collaboration on a difficult mathematical problem.

This project has explored the kind of infrastructure that needs to be in place to conduct distance learning on this scale: regional centers that coordinate local training for teachers; centrally produced videotapes to introduce common frameworks and procedures and to motivate participants; carefully designed, tested, and revised curriculum projects customized to fit the network; organization of working groups so that enough people are collaborating in a cycle of data collection to sustain participation and interest; hardware and software specifically created to support these well-structured activities.

An additional project, the Global Laboratory Project, is just getting under way. The Global Laboratory Project fosters global collaboration through an electronic network of teachers, students, and scientists. Participants will collect local field data about problems in global ecology and climatic change, and the data will be shared internationally. In concert with this collaborative activity, schools will engage in data analysis, model building, and experimentation.

Over the last decade, these projects have gone a long way toward solving practical, logistical, and conceptual problems of a particular interpretation of distance learning. The basis of the projects is collaborative inquiry in scientific or mathematical communities separated by geography. Thus this form of distance learning is doubly well grounded, in a familiar mode of professional activity as well as in collaborative learning in classrooms.

The distance-learning activities have been carefully designed around data collection and the sharing of ideas in the context of precisely focused problems. The reasons for establishing communities with distant partners are transparent, but the mechanisms for making them work require considerable effort. For

example, participating classrooms need to be moving in a coordinated fashion through the same data-collection cycle or else the community breaks down. Collaborating groups need to be formed and maintained through detailed scheduling procedures and central coordinators. Practice activities are designed to introduce newcomers to the requisite procedures and ready them for actual scientific collaboration; software and interface features must continue to be refined and customized to support successful engagement.[15]

The discourse that takes place in this science or math inquiry context is beginning to be studied[16]—how often the network is used by whom and for what topics. One interesting feature of these projects is that students work on a large shared data set that they themselves have created and can use locally for their own analyses. Issues of quality control arise in some classrooms concerning, for example, the correctness of the information that is communicated. Some teachers act as gatekeepers; others consider incorrect information that introduces variability into data as a good opportunity to learn important concepts in data analysis.

Writing and Publishing Through Newspapers and Journals

Another group of projects has taken a similar approach to distance learning through telecommunications, but focuses on a different field of activity—newspaper and journal publication—incorporating electronic networks into other subject domains, such as language arts and social studies.[17] These were among the first experiments to enlist distance learning technologies for collaborative learning and global exchange. For example, students in San Diego were linked to students in Israel, Mexico, and Japan to share information about problems in their local communities and ideas for solutions. From information exchanges that were relatively unstructured with respect to classroom activities, these projects developed a type of activity structure organized by publication. This familiar structure, extended through the new technologies, took care of problems created by the asynchrony of communications over the network, and the need for a focal activity that would lead to a shared product. It is also clearly related to the real activities of news services.

Currently, the group of projects includes the AT&T Learning Circles Project, involving several hundred schools in North America, Europe, Australia, and Japan. As in the TERC model, telecommunications software, print materials that structure a specific joint activity, and a central coordinator are provided to schools that join a Learning Circle. High school social studies classes, for example, join a networked Global Issues Learning Circle organized around investigation of a particular problem that is of national or international concern—for example, terrorism and self-determination; the role of women in society—and the creation of a journal that analyzes the issues from multiple points of view. Students in each class investigate some aspect of the issue—such as women and political power—provide local data to other members of the circle who are focusing on a different aspect—such as women in the work force—and coordinate the electronic publication of the final journal. Other tasks grow out of the same basic activity structures to create a joint newspaper written by elementary school students in collaborating classrooms; each group is responsible for a different section of the paper.

In early implementations, classrooms exchanged discs through the mail because it was easier and cheaper for schools than the available electronic means. Over the years, these technological problems were resolved, and the format of cocreating published materials became increasingly refined as a way to coordinate cross-classroom activity. For example, one class might take responsibility for editing a sports section of the newspaper and solicit information about the sporting events from other classes in Los Angeles, Fairbanks, and Honolulu, while another class would do the same for the science section. Students can also exchange information about how national or global news events are reported in their local press. This activity structure offers interesting solutions to some other problems. Classroom activities off the network are organized to allow groups of students to work together as writing and editorial boards, soliciting new information over the network, editing what is received, and returning it for review. Thus collaborative writing and information exchange can sustain cycles of discourse through distance-learning media. In addition, the issue of quality control of information is a task that is built into the activity structure itself through distributed editorial-review procedures.

Considerable research has been done on these projects, documenting their development. Rich descriptions are available about their use by teachers and students. Studies have also been done to examine how cycles of work within schools—daily, weekly, yearly—

affect the network activity and particular discourse properties of such exchange.

The *Jason* Project

The Jason Project is an experiment with a different kind of distance-learning technology—satellite-based interactive video. It exemplifies a second generation of design, using the technology to create a new kind of interaction. It is a complex project, involving multiple coordinated players: a scientific institute, communication technology and broadcast groups, curriculum development groups—both print and film; and 12 museums around the country. The project is based on the technologies created for research expeditions being conducted by Woods Hole Oceanographic Institute. One of their scientists, Robert Ballard, uses the small remote-controlled video-linked submarines—*Argo and Jason*—to conduct ocean-floor archaeological investigations. Video cameras linked by fiber optics to the shipboard scientists allow them to see through *Jason's* eyes in order to precisely control its actions and monitor its discoveries. The discovery of remains of the Titanic was one of the more famous achievements of *Jason's* brother, the remote robot vessel *Argo*.

The basis of the *Jason* Project is the field trip, where the students make special visits to places outside the school. After intensive in-class activity and preparation, students in fact do go to a local museum, but the field-trip notion is extended by transporting students via video from their museum headquarters to the deck of the scientific vessel, in real time. Through the satellite link, students are able to interact with scientists on board the ship and, like the scientists, to directly observe what *Jason* sees as it travels around the ocean floor. In one activity, the distant students can be given real-time control of *Jason's* movements. This project design is an interesting image of the use of scarce resources, extending beyond the model of teachers' being projected into traditional classroom organizations.

This extends a rare opportunity to a much larger number of students for interactive experience of scientific field activity. The activity structure for this project was very closely designed so that intensive within-classroom activity carefully prepared students for the central and actual one-hour distance-learning event. The brief use of distance-learning technology was surrounded by an abundance of within-school preparatory activity designed to focus the students' motivation around the special event and hone their perceptions about what they would see. These support experiences are designed to lead up to maximum value for the remote encounter.

The issue of community creation is also an interesting one in this context. It was found that students had some difficulty locating themselves aboard ship with adult scientists—the experience seemed quite foreign and distant. Featuring young students as actual members of the shipboard crew allowed students better to identify with the distant experience. In addition, with respect to quality control, if the students are given remote command of the robot vessel, how does one monitor their distant control over Jason's movements so that they do not drive the submarine into rocks?[18]

The Continents Project

The Continents Project was designed to experiment with a very different form of distance collaboration between educational institutions from what is now the norm. The notion was to create a new kind of community of faculty, who would share their course materials in a particular mediated and asynchronous way. The project was to explore technology as a means for democratizing information, since the intercollege community is created to share a live, malleable corpus of electronically resident materials, comingled rather than centrally reviewed and edited. In the process, there was the potential for the emergence of a new kind of nationally distributed community of interdisciplinary faculty, joined by their teaching responsibilities and materials rather than through discipline-based research interests. The project is based on an especially well designed hypermedia system developed at the Institute for Research in Information and Scholarship at Brown University.[19] Hypermedia allows users to link information—text, graphic images, animated graphics, video, sound-together, creating paths through bodies of related materials, annotating materials, and creating nodes that direct users elsewhere. The system has been shown to promote interdisciplinary links between subject areas as well as particular critical thinking skills on the part of the students.[20] It encourages new ways of designing courses, offering students new kinds of course materials to support their study. In courses supported by the software system *Intermedia*, students are encouraged to examine established and

novel relationships within and across disciplines, thinking critically about these links and adding their own materials, link structures, questions,and criticisms to the material.

The Continents Project grew out of the initial design and testing of the *Intermedia* system at Brown. It took as its goal the collaborative building of a large, integrated, interdisciplinary corpus in this hypermedia environment by a big group of faculty across North America. In the pilot and planning phase, 25 institutions represented the range of higher education institutions, from large and diverse university departments to single-faculty departments in small isolated colleges. A goal was to involve significant numbers of institutions with limited resources. Each faculty member was to create an *Intermedia*-resident corpus of his or her course materials that would be shared with all the others. All materials would be centrally coordinated to merge the link structures and distribute them to all participants for local use, revision, critique, and so on. While the funding for the major version of this project never materialized, the detailed planning work revealed a very interesting set of questions for a different form of distance learning, and smaller versions of the project have sprung up among original participants and others who were intrigued by the design. Many of the same questions are being confronted by the publishing industry, which is now grappling with the opportunities and changes engendered by electronic publishing.[21]

Such a large cocreated hypermedia-based corpus of materials is locally malleable in new ways, multiply usable, and live because it will undergo constant modification and addition. The "liveness" of the form across distances and multiple sites raises interesting questions about canonical form—is there one? In this design, there is no stable and complete version of the document that is distributed by a central publishing house, and novices as well as experts may have access to the body of material and modify it.

The community is primarily created not through direct communications but indirectly, through modifying and critiquing the corpus. The time frame of exchange in this community is thus on a slow scale because the conversation function takes place in the materials. What is exchanged is not data per se but interpretations of knowledge and traces of understanding that are left by creating structures of interdisciplinary links.

It was possible that such distance-learning exchanges might enable new kinds of mentor relationships to spring up between experienced and new faculty. For example, a master's conceptual organization for a course or topic can be viewed by examining his or her link structure in the corpus and by examining the critiques the master writes in his or her bridge documents that interconnect its parts. The necessary features and practical problems of coordinating this activity are unresolved and complex, but the organizing principle—the college course and its supporting materials—makes the initial tasks clear and familiar to participants.

Research Agenda

There is now a decade of experience in implementing a variety of distance-learning projects. Many of the projects are ongoing, and new ones continue to emerge. In general, the first phase of research that accompanied these implementations asked questions about the creation of images and models—how is this potential creatively used in learning environments, what are the best designs, and what kinds of support are needed to make these models robust and to sustain them?

Now the second phase of research in distance learning needs to be given coordinated attention. What are the consequences of these new circumstances for student learning and thinking and for the social aspects of schooling experiences? In what specific terms should the variety of distance-learning projects be held accountable? On the one hand, they need to be examined for their success in achieving their own stated goals for implementation and for learning and social outcomes. On the other hand, they can be examined in relation to their implications for a broad program of change in schools. The framework for learning environments previously introduced suggests some key qualities of engaged, individualized, and humane circumstances.

The set of five issues outlined earlier—technology, community, discourse, activity structure, and quality control—is one way of structuring the organization of an inquiry to first analyze features of distance-learning experiments. Particular compositions of features can be examined in relation to their consequences for students' development as they experience the mediating technologies. How does the work that

students accomplish—individually or collaboratively—relate to the specific experiences in distance-learning settings? How did the distance-learning designs integrate with the regular classroom activity? Process-product studies of student work should be undertaken in a variety of distance-learning settings.

With respect to the social organization of learning, there are parallel process-outcome questions. If we are interested in whether distance learning helps students to develop a broader perspective about issues and ideas—through exchange with national and global partners—then we need to study whether and how perspectives change in the course of the experiences. Longitudinal inquiry would be useful, as these realms of knowledge are likely to develop slowly over months or years. In addition to monitoring how electronically mediated communities and discourse forms develop and are structured, it would be useful to study how they affect the development of students' enlarged perspectives on issues they study and the qualities of their relationships with collaborators.

Ultimately, the goal is to understand what designs for distance learning are effective for cognitive and social development. We argue that the kinds of indicators previously discussed for high-quality learning environments combined with the issues particular to distance learning can be used to describe the features of particular designs and their outcomes. We want to create enriched environments, not just to experiment with interesting technologies, but to support more effective educational practices. Holding the designs accountable to this broader set of goals can only be done by analyzing the social and cognitive environments that are created. ✦

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